

2193 THE
U S E
OF THE
GE-ORGANON
AND
IMPROVED ANALEMMA,
Or SUBSTITUTES for the
TERRESTRIAL and CELESTIAL
GLOBE.

Invented by B. DONNE,
Teacher of the MATHEMATICS and NATURAL PHILOSOPHY,
at BRISTOL.

Price of the Ge-organon in Sheets 6s. 6d. ; but if fitted up with move-
able Hour Circles, &c. 10s.—Of the Analemma 3s. 6d. and of
this Pamphlet 1s.

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The DESCRIPTION and USE
OF THE
GE-ORGANON.

THOUGH we have called, in the Title-page, the GE-ORGANON and IMPROVED ANALEMMA *Substitutes* for the *Terrestrial* and *Celestial Globe*, yet we would not be thought to wish to discard them as uselefs; but would advise the Head of every Academy, or Ladies Boarding School, where convenient, to have a Pair of Globes, as they will in some Cafes be better adapted to give Lectures on, for conveying general Ideas; But it cannot be expected that every Parent will purchase a Pair of Globes of a proper Size; though it is absolutely neceffary that every Geographical Pupil fhould have fome convenient Instruments to praftife on, when learning, and to enable him to retain the Principles after learnt. This led me feveral Years fince to publish the *Improved Analemma* for folving the Problems of the *Celestial Globe*, and afterwards *A Panorganon* for thofe of the *Terrestrial*; but as the *Panorganon* was on fo fmall a Scale as to admit of, and defigned only to fhew the Capital of each Kingdom, and great Discoveries have been fince made, by the Voyages of our late celebrated Navigator Captain Cook and others, I have been inclined to delineate one on a much larger Scale; and have conftituted it in a Manner fo very different as to require different Methods of Working, &c. and therefore, now give it to the World as a *New Instrument* under the Title of the GE-ORGANON. It may not be amifs to acquaint fuch of my Readers as have not had a Claffic Education, that the Name is compounded of two Greek Words, *Ge* the Earth, and *Organon* an Instrument.— Thefe Instruments will really folve moft Problems as readily, and fome more accurately than the Globes themfelves, and, on account of their Portablenefs, will be found ufeul even to thofe who have them. I flatter myfelf that thofe Teachers of Geography who will be pleafed to introduce them, will find them to contribute much to the Improvement of their Pupils.

The GE-ORGANON consists principally of Maps, on two Sheets of Royal Paper.

Plate the First or Sheet 1st. contains a Map of the Northern Hemisphere, and a Chart of the Western Half of the Torrid Zone.

Plate the Second or Sheet 2d. contains a Map of the Southern Hemisphere and a Chart of the Eastern Half of the Torrid Zone.

These Plates besides the Maps and Charts contain several Appendages, as will be particularly described.

Each Hemisphere is an *Orthographic Projection*, on the Plane of the *Equator*; by which Means the *Pole* is in the Center, and the *Meridians* become right Lines, as they are right Circles on the Terrestrial Globe.

The *Parallels of Latitude* in this Projection, are concentric Circles about the Pole, and manifestly parallel to the Equator, as they are on the Globe.

It may perhaps be objected, that the Degrees of Latitude diminish very much towards the Equator, and consequently the Places near it will be much shorter from North to South, than they are with respect to their Breadth, from East to West on the Globe. In answer to this, it is well known to those who are well acquainted with the Subject, that it is impossible on any Principle of Perspective; to observe the real proportional Magnitudes in a Delineation on Paper. That we must judge of their Length and Breadth, by the Number of Degrees they extend, and not from their apparent Magnitude.

If the *Stereographic Projection* had been made use of, the Degrees would have been shorter near the Pole, and wider as they approached the Equator.

There is an arbitrary Projection sometimes used, called the *Globular Projection*, not founded on any Principle of Perspective; but to make the Places appear nearly of the same apparent Magnitude, as they are on the Globe; and if it had been designed only to have made a Picture, this would have been preferred.

The Preference has been given to the first or Orthographic Projection, in constructing the *Ge-organon*; principally, because the Degrees of Longitude, or Distance of Meridians decrease in this, as they approach the Pole, in the same Proportion as they really do on the Globe, which is peculiar to this Projection, and very naturally explains the Nature of Parallel Sailing in Navigation. I have said thus much to take off the Cavils of some ignorant Critics; who not seeing the Advantage of this Projection, might possibly be glad to point out its Defects.—However, I think it not worth while to spend any more Time on this Head; and therefore shall only observe farther, that as it is principally near the Equator that the Degrees of Latitude are much

much contracted in this Projection, making the Land appear very different in Figure, &c. from what it is on the Globe, I have, to remedy that Defect, given two Charts of the Torrid Zone, as above mentioned, containing all the Land between the Parallels of $23^{\circ} : 2'8$ North Latitude, and $23^{\circ} 2'8$ South, in as true Proportion as on the Globes; which serves also to shew how the two Hemispheres connect together.

Without the Equator are several concentric Circles contained in a Kind of Ring or Hoop, which we shall call the *Equatorial Ring*, and Colour Yellow, for Distinctness Sake. The innermost Circle of this Ring, or Hoop, is the Equator.

In this Ring the Longitude is counted several Ways to answer different Purposes. It has the Longitude counted from the Meridian of London one Half the World or 180° East, and the other Half 180° West, agreeable to the Method followed by most of the English. It is also counted all round East from London, agreeable to Captain Cook's last Voyage.—Again, in the outermost Part it is counted all round the World East from the Island of Ferro, to agree with the Method chiefly followed by the French, and also of some English. The Equatorial Ring is also divided into Hours and Minutes.

In the upper Right Hand Corner of the Hemispheres are Scales for shewing by Inspection the Sun's Declination answering to any Day of the Month.

In the Right Hand Corner at the Bottom of the Northern Hemisphere is a Scale made in Form of a Carpenter's Square, marked A C B, for finding the Distances of Places, &c. And a Quarter Part of a Compass for finding the Courses, which as it is there made, serves instead of a whole Compass.

To the Pole of each Hemisphere a Silk String has one End fixed, which serves instead of a General Meridian.

The Hemispheres when fitted up have also moveable Hour Circles for the more readily solving Problems, when it is required to find the Time at one Place when it is a given Hour at some other Place.

Captain Cook's Tracts in his three Voyages are laid down on both Hemispheres.—In order to be as compendious as may be, we suppose our Reader acquainted with the first Principles of Geography, or, that he has the Benefit of a proper Instructor, and then the following may be readily understood.

The General Principles of working on the Globes or Ge-organon are the same, only as the General or Brazen Meridian is fixed, and the Globe moveable, the given Place is brought to the Meridian; but in the Ge-organon the Plates being fixed, the Silk String, our General Meridian being moveable, is brought to the Place. Also on most Globes the Hour Circle being fixed and the Index moveable, the Index is set to the given Hour,

Hour, but our Hour Circle being moveable is set to the given Hour; as will be clearly explained in the following Problems:

PROBLEM I. *By the Latitude and Longitude of a Place to find it on the Instrument.*

SOLUTION. Find the Longitude of the Place on the Equatorial Ring, and lay the String (which serves for a General Meridian) on it; then under the String in the Latitude of the Place, you will find the Place required; if it is inserted in that Hemisphere.

If the Latitude of the Place is less than $23^{\circ} : 2'8$ you may look for it in the Chart of the Eastern or Western Part of the Torrid Zone, as it may be in East or West Longitude.—Thus for Example, In Latitude 18° North and Longitude 77° West, in the Western Part of the Torrid Zone we shall find the Island of Jamaica.

PROBLEM II. *To find the Latitude and Longitude of any Place on the Hemisphere.*

If the Place is in North Latitude take the Northern Hemisphere; but if in South Latitude the Southern. Then lay the String over the Place and it will cut the Longitude on the Equatorial Ring; then the String being kept in that Position, if the Place is on any Parallel Circle drawn on the Hemisphere you have its Latitude by Inspection; but if it is Northward or to Southward of the Parallel, take the Distance from the Parallel with a Pair of Compasses, and applying it to a Graduate Meridian you will have its Latitude.—

Thus for Example, Paris the Capital of France, will be found to be in Latitude 49 Degrees North, and Longitude more than 2 Degrees East of London,

N. B. If the Place lies in the Torrid Zone or in Latitude less than $23^{\circ} \frac{1}{2}$, its Latitude may be found more accurately by inspecting the Chart of the Torrid Zone.

PROBLEM III. *To find all those Places of the same Longitude as a given Place.*

Lay the String over the given Place, then all Places lying under the String have the same Longitude.

PROBLEM IV. *To find all those Places of the same Latitude as a given Place.*

Find the Latitude of the Place by Problem II. and if it lies on a Parallel Circle, all Places that Parallel passes over will have the same Latitude; but if it lies at some Distance from a Parallel, take its Distance from it with a Pair of Compasses, then will all
Places

Places at that Distance from that Parallel, and on the same Side, have the same Latitude as the given Place.

PROBLEM V. *By having given the Longitude of any Place according to the English Method of counting the Longitude (one Half the World East, and the other Half West) to find the Longitude counted from Ferro all round East; as given in most French Maps, and some English; or to the Longitude as in Cook's last Voyage round the World, which is counted all round East from London.*

Lay the String over the given Place; or to its English Longitude on the Equatorial Ring; then may be seen by Inspection what the required Longitude is from Ferro in the outermost Circle, and from London East according to Cook's Voyage in the innermost Circle.

EXAMPLE. Looking into an English Gazetteer, or on the Northern Hemisphere, I find Jamaica is in Longitude 77 Degrees West from London. In what Longitude must I look for it in a French Chart, which counts its Longitude from Ferro, East? or in the Chart of Cook's last Voyage.

ANSWER. In the French Chart, in Longitude 300° East of Ferro, or in Cook's Chart in Longitude $28^{\circ}3'$ West from London.

PROBLEM VI. *To change Longitude according to the French Method from Ferro (counted all round East) to the English Method of counting (one Half East, the other West) from London. Or by having the Longitude agreeable to Cook's Chart, to the Longitude according to the common Method (one Half East the other West from London).*

This being only the Reverse of the last Problem, needs no particular Directions.

EXAMPLE. Reading in a French Book of a Transaction which happened at a Place in 139° East of Ferro, where must I look for it in an English Map, which counts Longitude from London.

ANSWER. In Longitude of about 122° East from London.

EXAMPLE 2. Reading in Cook's last Voyage that Owhyhee, where Capt. Cook was killed, was in Longitude of about 205° , where must I look for it in a common English Map?

ANSWER. In Longitude of about 155° West from London.

These two Problems, though exceeding useful to young Geographers, is not readily solved by any Globes I have hitherto met with.

PROBLEM VII. *The Longitude of a Place being given in Time from London, to turn it into Degrees of Longitude.*

Lay the String over the given Time in the Circle of Hours on the Equatorial Ring, and you will see by a bare Inspection how many Degrees are equal to those Hours, or the Longitude in Degrees East or West from London; and at the same Time by Inspection the Longitude from Ferro, or from London, agreeable to the Method of counting Longitude in the Chart of Cook's last Voyage.

N. B. If the Longitude is East of London you must count by the Numeral Hours 1, 2, 3, &c. not by the Clock Figures, XI. X. IX. &c.

EXAMPLE. Moscow is in Longitude 2 Hours 31 Minutes East of London, required its Longitude in Degrees.

ANSWER. $37^{\circ}\frac{1}{4}$ East of London, or about 55° East of Ferro.

N. B. The Hours in the Northern Hemisphere are subdivided into every five Minutes of Time; and was so intended by the Author for the Southern Hemisphere; but the Engraver has in that divided the Hours into every 6 Minutes of Time.

PROBLEM VIII. *The Difference of Longitude between London and any Place being given in Degrees to find the Difference of Longitude in Time.*

This being only the Reverse of the last, needs no particular Directions.

For EXAMPLE. $37^{\circ}\frac{1}{2}$ West Longitude from London, corresponds to 2 h. 30' W. in Time.

PROBLEM IX. *To find the Difference of Latitude between any two Places.*

Find the Latitude of each Place by Problem II. Then if both Places are in North, or both in South Latitude, subtract the lesser from the greater Latitude, and the Remainder will be the Difference of Latitude required.

But if one Place is in North and the other in South Latitude, add them together, for what is called (but improperly) the Difference of Latitude.

EXAMPLE. What is the Difference of Latitude between London and Paris?

ANSWER. London being in Latitude $51^{\circ} 32'$ N. and Paris in $48^{\circ} 50'$ N. their Difference of Latitude is $2^{\circ} 42'$.

EXAMPLE 2. What is the Difference of Latitude between London and the Cape of Good Hope?

ANSWER.

ANSWER. The Latitude of London being $51^{\circ}:32'$ N. and the Cape Horn $55^{\circ}:58'$ S. their Sum gives $107^{\circ}:30'$ for their Difference of Longitude.

PROBLEM X. *To find the Difference of Longitude between two Places.*

Find the Longitude of each Place by Problem II. Then if the Places are both in East, or both in West Longitude, subtract the Lesser from the Greater, and the Remainder will be the Difference of Longitude: But if one Place is in East Longitude, and the other in West, add them together, and their Sum, (if it exceeds not 180°) is called the Difference of Longitude; if more than 180° , subtract from 360 Degrees.

Or if you count the Longitude all round the World East, always subtract one Longitude from the other, and the Remainder, if not more than 180° , is the Difference of Longitude; if more, subtract that Remainder from 360 Degrees, for the Difference of Longitude.

EXAMPLE I. What is the Difference of Longitude between Paris and Jamaica?

ANSWER. Port Roval in Jamaica being in Longitude of about 77° W. and Paris in about 2° East, their Sum 79° W. is the Difference of Longitude required.

EXAMPLE 2. What is the Difference of Longitude between the Lizard and Jamaica?

ANSWER. 72° .

EXAMPLE 3. What is the Difference of Longitude between the Island of Owhyhee 155° West, and the Island of St. Bartholomew in 165° East.

Their Sum is 320° , which subtracted from 360° , gives 40° for the required Difference of Longitude.

PROBLEM XI. *To find the Place whose Inhabitants are called Antoeki, with respect to a given Place.*

The Antoeki live under the same Meridian, but opposite Parallels of Latitude. Therefore find the Latitude and Longitude of the given Place, then find on the other Hemisphere a Place in the same Longitude and the same Number of Degrees of Latitude, and that will be the Place required; Thus, for Example, the Antoeki to London falls in the Great South Sea, in Latitude $51^{\circ}\frac{1}{2}$ South, and Longitude 0 Degrees.

PROBLEM XII. *To find the Place whose Inhabitants are called Perioeki, with respect to a given Place.*

The Perioeki live under the same Parallel of Latitude, but opposite Meridian. Therefore, find the opposite Meridian by

laying a Ruler or Scale on the given Place and the Pole, or by laying a String on the given Place and the Pole, and extending it till it reaches the Equatorial Ring on the other Side of the Pole; then under that opposite Meridian, in the Latitude of the given Place will be the Perioeki required.

Thus for Example, Fort St. George or Madras in the East Indies, will be found to be nearly Perioeki to Vera Cruz in the Gulph of Mexico.

PROBLEM XIII. *To find the Antipodes to a given Place.*

The Antipodes live under opposite Parallels of Latitude and opposite Meridians. Therefore by Problem II. find the Latitude and Longitude of the given Place, then on the other Hemisphere lay a String or Ruler over that Longitude and over the Pole to find the opposite Meridian; then under the Latitude on that opposite Meridian will be the Place of the Antipodes required.

EXAMPLE. The Antipodes to London falls in Latitude $51^{\circ} \frac{1}{2}$ South, and Longitude 180° , at a considerable Distance from any known Land, the nearest to it is New Zealand. But if we find the Antipodes to Gibraltar, the Place falls near Cape Colvil in New Zealand.

PROBLEM XIV. *When it is Noon at any given Place, to find what Hour it is at any other given Place.*

Lay the String on the Place where it is Noon, and bring Noon on the moveable Plate or Hour Circle to it, then laying the String on the Place where the Time is required, or on its Longitude if it is not in the same Hemisphere, and the String will cut on the Hour Circle the Time required.

But if the Ge-organon is not fitted up with a moveable Hour Circle, or you would wish to have the required Time more accurately than can be done by the moveable Hour Circle, as suppose to a Minute or two; then laying the String over each Place see the Longitude of each from London, in Hours and Minutes, on the Equatorial Ring. Then if the Places are both in East or both in West Longitude, the Difference of the Hours and Minutes will be the Difference of Longitude in Time: But if one is in East and the other in West Longitude, the Sum of both the Longitudes in Time will be the Difference of Longitude required, if the Sum exceeds not 12 Hours, if it does, subtract that Sum from 24 Hours, and the Remainder will be the required Longitude. Then if the Place where the Time is required is to the Eastward of the Place where the Time is given, the Time there will be so many Hours later; but if to Westward so many Hours sooner. And this Rule may serve in general

general whenever the Time at one Place is given to find the Time at the other.

EXAMPLE. When it is Noon at London, what o'Clock is it at Jamaica?

ANSWER. By working by the moveable Hour Circle it will be found to be about $6\frac{1}{4}$ in the Morning at Jamaica when Noon at London. But if we make Use of the Hours on the Equatorial Ring, we shall find the Difference of Longitude between London and Jamaica 5 h. '8; and Jamaica being to Westward of London, subtracting 5 h. '8, from 12 Hours or Noon at London we get 6 h. 52' the Time in the Morning at Jamaica when Noon at London.

PROBLEM XV. *To find all those Places where it is Noon when it is a given Hour at any given Place.*

Lay the String over the given Place, and bring the given Hour under the String, then laying the String over 12 at Noon; observe the Longitude, then it will be Noon to all Places under the String in that Hemisphere, and also to all Places in the other Hemisphere having the same Longitude.

But if you have no moveable Hour Circle to your Ge-organon, consider, that if the given Hour is in the Morning, the Places where it is then Noon must be as many Hours to the Eastward of the given Place as the given Time is before Noon; but if the given Time is in the Afternoon, they must be as many Hours to the Westward of the given Place as the Number of Hours in the Afternoon given.

EXAMPLE. Thus, when it is $\frac{1}{2}$ after 5 in the Evening at London, at what Places is it Noon?

ANSWER. At all Places in $82^d\frac{1}{2}$ West Longitude; hence, it is Noon at that Time at Hudson's Bay, Part of Virginia, Georgia, Cuba, Porto Bello, Panama, &c. in the Northern, and at Lima and Cape Horn in the Southern Hemisphere.

PROBLEM XVI. *At any given Hour of the Day at any given Place, to find the Hour of the Day at any other given Place.*

Lay the String over the Place where the Time is given, then bring the given Time on the moveable Hour Circle under the String; this done, lay the String over the Place where the Time is required, and it will shew the Time at that Place on the Hour Circle. N. B. If one Place is in one Hemisphere, and the other on the other Hemisphere, as you cannot bring the second Place to the String, bring its Longitude instead of it.

But if the Ge-organon is not fitted up with moveable Hour Circles, or you are inclined to work by the Hours on the Equatorial Ring, the Solution will be something more troublesome.

To do this you must find the Longitude of each Place in Time, and their Difference of Longitude in Time as shewn in the Solution in Problem XIV. &c.

EXAMPLE. When it is 8 at Night at London, what o'Clock is it at Pekin in China?

ANSWER. By working by the moveable Hour Circle, the Time required at Pekin will be found to be about 3 h. $\frac{3}{4}$ in the Morning. But if we work by the Hours on the Equatorial Ring, by Problem XIII. the Difference of Longitude in Time between London and Pekin, is 7h. 48', and Pekin being to Eastward of London, it must be so much later at Pekin, therefore to the Time at London 8 Hours add the Difference of Longitude 7 h. 48', the Sum is 15h. 48', from which taking 12 Hours gives 3 h. 48' in the Morning.

SCHOLIUM. Hence it follows that on Account of the Hour Circle on the Equatorial Ring being much larger than the moveable Hour Circle, the Time may be found to a greater Degree of Accuracy than by the moveable Hour Circle; but as it is more troublesome, and requires some Judgement to use it, the moveable Hour Circle will by young Students be generally preferred, as its Use is equally easy with the Hour Circle and Index on a Globe, and as accurate, as the Time may be found by it to less than a Quarter of an Hour.

PROBLEM XVII. *The Day of the Month being given to find the Sun's Declination, that is, how many Degrees the Sun is to the Northward or Southward of the Equinoctial.*

This is seen by Inspection only, on the little Tables for that Purpose, in the upper Corners of the Plates.

EXAMPLE. On the 3d of June the Sun's Declination is $22^{\circ} \frac{1}{2}$ North.

PROBLEM XVIII. *By the Sun's Declination to find the Day of the Month.*

This being only the Reverse of the last, requires no particular Directions.

PROBLEM XIX. *To find all those Places the Sun will be vertical to, on a given Day.*

Find the Sun's Declination, then all the Places whose Latitude is equal to the Sun's Declination, and of the same Name, will have the Sun directly over Head that Day.

EXAMPLE. Thus it will be found that on the 9th of May and 3d of August, the Sun passes directly over Head to Jamaica, &c.

PROBLEM XX. *To find what Day the Sun will be vertical to a given Place in the Torrid Zone.*

Find the Latitude of the Place, then observe in the Tables of Declination what Days the Sun's Declination is equal to the Latitude and of the same Name, for they are those required.

The Reverse of the last Example will serve as an Example for this Problem.

PROBLEM XXI. *To find the Place where the Sun is vertical when it is any given Hour at a given Place.*

First find the Sun's Declination for the given Day. Lay the String over the given Place, and bring the given Hour on the moveable Hour Circle to it; keep the Hour Circle in that Position and lay the String over the Hour of 12 at Noon (as the Sun cannot be vertical to any Place but at Noon) then under the String in that Latitude which is equal to the Sun's Declination, will be the Place required.

EXAMPLE. Where is the Sun vertical the 3d of June when it is 7 o'Clock in the Morning at London?

ANSWER. The Sun is vertical at that Time to a Place in Longitude 75° East, and Latitude $22^{\circ} \frac{1}{2}$ which falls in India West the Ganges, near Aurungabad.

PROBLEM XXII. *To find what Places may possibly see a particular Transit of Venus, of Mercury, or an Eclipse of the Sun.*

Find where the Sun is vertical by the last Problem, then all the Places that are not more than 90 Degrees distant from that Place, will have the Sun above their Horizon, and consequently, if there is a Transit, or an Eclipse of the Sun may possibly see it. But whether the Transit of Venus and Mercury, or Eclipses of the Sun and Moon, or Occultation of the Stars, may be seen at any particular Place, is better done on the Analemma, by which may easily be found the Time of the Sun's, Stars, Planets, or Moon's rising, southing or setting, or Height above, or Depression, under the Horizon for any Time, and consequently, whether the Object be visible or not.

The Writers on the Use of the Globes give this Problem absolute, and say the Transit or Eclipse may be seen by all Places within the Distance of 90° from the Place where the Sun is vertical: But it is well known to all Persons who understand calculating Eclipses, &c. that on Account of what is called the Parallax, there may be a Transit or Eclipse of the Sun at one Place and not at another at the same Time, though the Sun be above the Horizon, and visible to all Places within 90 Degrees of the Place where the Sun is vertical.

PROBLEM XXIII. *To find what Places may see an Eclipse of the Moon.*

Find by Problem XXI where the Sun is vertical, then as the Moon in an Eclipse is directly opposite to the Sun, the opposite Place to that where the Sun is vertical will be the Place where the Moon is vertical. Therefore find by Problem XIII the Antipodes to the Place where the Sun is vertical, and it will be the Place where the Moon is vertical. And consequently all Places that are not more than 90° distant will see the Moon; and the Eclipse (if a clear Sky). For, an Eclipse of the Moon is a real Eclipse, and has the same Quantity of Digits eclipsed at the same Moment of absolute Time, to all Places where she is visible, and does not at all depend on the Situation of the Spectator as in an Eclipse of the Sun.

PROBLEM XXIV. *To find how many Miles make a Degree of Longitude in any Latitude, or in other Words, how many Miles a Ship must sail on an East or West Course in any Latitude to alter one Degree of Longitude.*

For this and like Purposes, on each circular Plate, are several Meridians graduated into Degrees. On the Northern Hemisphere that which is freest from being obscured by Land, and therefore the Graduations most distinct (and consequently fittest for this Purpose) is the Meridian opposite to the Meridian of London, and is named on the Plate *A Graduated Meridian*.—On the Southern Hemisphere either of the Four Graduated Meridians are distinct enough, neither of them passing over any Land.

The Method of solving this Problem is, From the Scale A C, or C B in the Right Hand lower Corner of the Plate of the Northern Hemisphere take 60 with a Pair of Compasses, which we now call 60 Miles, (the Number of Miles which make a Degree of Longitude on the Equator) then placing one Leg of the Compasses in 0 Degree of Latitude on the Graduated Meridian, let the other Leg rest on the Equator, and bring the String to it. Then extend the Compasses from the given Latitude under the String to the same Latitude on the Graduated Meridian, and that Distance measured on either the Scale C B, or C A, will give the Number of Miles required.

N. B. If the Latitude does not fall exactly on a Parallel Circle drawn on the Hemisphere, it would be proper after the String is fixed in its proper Place, to take how many Degrees the given Latitude is to Northward or Southward of the Parallel Circle near it, and setting that Distance from the Parallel Circle by the Side of the String you will be certain of the Place where to fix one Leg of the Compass; then extend the other to the same Latitude on the Graduated Meridian, &c,

EXAMPLE,

EXAMPLE. In Latitude of 60 Degrees, it will be found that 30 Miles make a Degree of Longitude: or that a Ship sailing on that Parallel, for every 30 Miles Distance, will alter one Degree of Longitude.

PROBLEM XXV. *To find the Course and Distance from one given Place to another.*

This admits of Three Cases.

CASE I. If the two Places are North and South of each other, their Difference of Latitude is their Distance, and therefore found as in Problem IX.

CASE II. When the two Places are both in the same Latitude.

The Course is then East or West, and their Distance may be thus found. Take the Number expressing their Difference of Longitude from the Scale, apply one End of the Compasses to 0 Degree of Latitude on the Graduated Meridian, and rest the other Leg on the Equator, and bring the String to it; keep the String in this Position; then extend the Compasses from the given Latitude under the String to the same Latitude on the Graduated Meridian, and this Extent being laid on the Scale, will give the Distance required.

EXAMPLE. What is the Distance from Madeira to Bermudas?

ANSWER. The Difference of Longitude being about 47 Degrees, the Distance is about 40° , which multiplied by 60, gives 2400 Miles.

CASE III. When the Places differ, both in Latitude and Longitude.

For the more readily seeing the Course from the Land's End of England, to any Place in the Western Ocean, I have laid down Curvilinear Lines, beings Rhumbs, by which the Course is known by Inspection.

The Distance between Places may be found thus: Take a middle Latitude between the Latitude of the two given Places, and with the Difference of Longitude and this middle Latitude, find a Distance as in Case 2d, which Distance we shall call Departure. Lay this Departure on the Scale from C, towards A, and note the Degree it falls on; then find the Number, expressing the Difference of Latitude of those two Places on the Scale, C. B. Then extend the Compasses from the Difference of Latitude on the Scale C. B. to the Departure on the Scale C. A. and that Extent measured on the Scale, will shew the required Distance. And if a Ruler or String be laid from the Place whereon the Point of the Compasses rested on C. B. viz. to the Place it rested on C. A. as suppose on ba , then does the Direction of that Line, or the Angle abc , shew how much the Course

is from the North or South, towards the East or West; and may be easily seen, by observing which Point of the Sea Compass is parallel to that Line.

EXAMPLE. What is the Course and Distance from the Land's End of England to Jamaica.

SOLUTION. The Latitude of the Land's End being 50° N; and of Jamaica 18° N, their Difference is 32° . The Longitude of Jamaica 77° W. and of the Land's End $5\frac{1}{2}^{\circ}$ West, the Difference of Longitude is $71\frac{1}{2}$ Degrees. Again, the Latitude of the Land's End 50° added to the Latitude of Jamaica 18° the Sum is 68 Degrees; Half of which is 34 Degrees for a Middle Latitude. With the Middle Latitude 34 Degrees and the Difference of Longitude $71^{\circ}\frac{1}{2}$ the Departure will be found as above directed to be 60 Degrees. And by the Difference of Latitude 32 Degrees, and the Departure 60 Degrees, the Distance will be found to be about 68 Degrees, which multiplied by 60 gives 4080 Nautical or Geographical Miles. Or by 20 gives 1360 Leagues. And the Course $5\frac{1}{2}$ Points from the South towards the West or S. W. b. W. $\frac{1}{2}$ W.

N. B. This finds the Course on a Rhumb Line, or the real Course, which if a Ship could keep always on, would carry it from one Place to the other; and the opposite Course would bring it back again. But what is found by working on the Globe by laying the Quadrant of Altitude over the two Places as directed in Books does not find the Course; but the Angle of Position, or bearing, of one Place from the other, and Distance on the Arch of a great Circle, which Navigators have nothing to do with. And if the Angle of Position of Jamaica from London was found on the Globe, it would be found that Jamaica from London bears about $\frac{1}{2}$ a Point to the Northward of the West; but that London bears from Jamaica not opposite or $\frac{1}{2}$ a Point to Southward of the East; but very different, viz. about N. E. b. N. $\frac{1}{2}$ East.

* * To find the Time of the Sun's Rising and Setting, Length of the Days and Nights and Problems relating to the Stars, &c. belong properly to the Celestial Globe, and therefore we refer for the Solution of those to our *Analemma*.



T H E

DESCRIPTION and USE

O F T H E

IMPROVED ANALEMMA.

THE moveable Circle is an orthographic Projection of the Sphere on the Plane of the Meridian.

The dotted Line which passes through the Centre is the *Equinoctial*, the Lines parallel to it are Parallels of Declination; and for the readier counting, every 5th Degree is engraved stronger than the others.

The Line which passes through the Center and is perpendicular to the Equinoctial is the *Axis*; one End of which marked with a Fleur-de-Lis is the *North-Pole*, as the other End marked S, is the South Pole.

The dotted Parallel of Declination $23^{\circ} \frac{1}{2}$ North of the Equinoctial is the *Tropic of Cancer*, as is that $23^{\circ} \frac{1}{2}$ South of the Equinoctial the *Tropic of Capricorn*.

The dotted Parallel $66^{\circ} \frac{1}{2}$ North of the Equinoctial is called the *Arctic* or Northern *Polar Circle*; that in the South, at the same Distance from the Equinoctial, is the *Antarctic* or Southern *Polar Circle*.

The dotted Line passing thro' the Center in an oblique Position making an Angle of $23^{\circ} \frac{1}{2}$ with the Equinoctial is the *Ecliptic*; it is divided by little Lines (") into every 5 Degrees, and subdivided into Degrees by Dots (..)

On each Side of it, at 8 Degrees Distance, is drawn a parallel Line, and the Space contained between these Lines is called the *Zodiac*, in which the *Planets* are always found, except the *Georgian Planet*.

The strong elliptic Lines, are *Hour Circles*; the less strong *Half Hours*; and those dotted are *Quarters of Hours*.

The large Plate contains the following Particulars, besides the *Meridians* and *Prime Vertical*, the *Horizon* S. N. which is divided into Degrees counted from the East or West Point towards the North and South, for finding the Amplitude of the Sun or Star: and under these Degrees, into Points and Quarter Points of the Compass, counted from the North or South towards the East or West, to shew readily on what Point of the Compass the Sun or

Star rises or sets, &c. And to know the corresponding Point of the Compass, in the Right-hand upper Corner is engraved a Compass, for such Youths as have not learnt the Sea Compass.

In the same Corner is * R. A.—◉ R. A. or

* R. A. + 24h—◉ R. A.
= * Southing.

which is to be thus read, The Stars Right Ascension *Minus* (or less) the Sun's Right Ascension: Or the Stars Right Ascension *Plus* (or more) 24 Hours *Minus* the Sun's Right Ascension is equal to the Stars Southing. The Use of this will be explained hereafter.

Under the Horizon on the Left Hand is a Calendar for our Summer, and on the Right another for our Winter half Year, containing the Days of the Month, Sun's Right Ascension, Place and Declination corresponding thereto, which we shall have Occasion to explain more particularly in the Problems.

In the Middle between the Calendars is a Table shewing the Right Ascension and Declination of the principal Stars; which being calculated for some Years hence, will be sufficiently accurate for many Years to come.

PROBLEM I. The Day of the Month being given to find the Sun's Place in the Ecliptic. This is done by Inspection of the Calendar only.

EXAMPLE. Thus it will be seen that the 20th of March the Sun enters *Aries*, the 20th of April *Taurus*, May the 21st *Gemini*, the 21st of June *Cancer*, the 23d of July *Leo*, the 23d of August *Virgo*, September 22d *Libra*, October 23d *Scorpio*, November 22d *Sagittarius*, December 21st *Capricornus*, January 20th *Aquarius*, February 18th *Pisces*

N. B. The Line for the Sun's Place is marked ◉ P and is divided into every 5 Degrees by Dashes (||) and subdivided into Degrees by Dots (..).

PROBLEM II. By the Sun's Place in the Ecliptic to find the Day of the Month.

This being only the Reverse of the former needs no particular Explanation.

PROBLEM III. By the Day of the Month to find the Sun's Declination. This may also be found by barely inspecting the Calendar. Thus for Example January 20th against that Day of the Month in the Column D. you will find the Sun's Declination 20 Degrees South.

But if the young Student is inclined to solve this Problem on the Analemma, it may be done thus. Bring the Equinoctial to the Horizon and the Southern Part of the Ecliptic above the Horizon, then looking for the Sun's Place corresponding to the Day of the Month (which in the present Example is ◉◉ Aquarius) observe

serve what Parallel of Declination crosses that Place, and we shall have the Declination; in the present Example 20° as afore found.

PROBLEM IV. By the Sun's Declination to find the Day of the Month.

This is also readily done by Inspection of the Calendar.

Let the Example be the Reverse of the last, viz. the Sun's Declination being 20° Degrees South, what is the Day of the Month? Answer, it appears by the Calendar that it may be either the 20th Day of January or the 21st Day of November.

If it be required to solve this Example on the Analemma, bring the Southern Part of the Ecliptic above the Horizon, and the Equinoctial in the Horizon, then will the Parallel of Declination, in our Example the 20th Degree, cross the Ecliptic in 0° of *Sagittarius*, and 0° of *Aquarius*, the two Places of the Ecliptic in which the Sun has that Declination. Hence by Problem IIId. the Days are as above.

PROBLEM V. To rectify the Analemma for any particular Place.

This is only to bring the Pole to the Latitude of the Place, the North Pole to the North Meridian if the Place is in North Latitude; but the South Pole to the South Meridian for South Latitude.

PROBLEM VI. To find the Sun's Amplitude, or on what Point of the Compass the Sun rises and sets at any given Place on any given Day.

Rectify the Analemma by the last Problem; and by the Day of the Month find the Sun's Declination, by Inspection of the Calendar as shewn in Problem IIIId. Then will the Parallel of that Declination cut the Sun's Amplitude on the Horizon.

EXAMPLE. On what Point of the Compass does the Sun rise and set at London (Latitude $51^{\circ}\frac{1}{2}$ North) the 20th of June? Working as above directed it will be found that the Sun rises E. 40° N. and sets W. 40° N. or rises nearly N. $4\frac{1}{4}$ Points E. and sets N. $4\frac{1}{4}$ W. which answer to N. E. $\frac{1}{4}$ E. and N. W. $\frac{1}{4}$ W.

PROBLEM VII. To find the Time of Sun rising and setting, Length of the Day and Night at any given Place, whose Lat. does not exceed $66^{\circ}\frac{1}{2}$.

Rectify the Analemma, and find the Sun's Declination for the given Day, then observe what Hour Circle cuts the Horizon, and it will shew how much the Sun rises before or sets after Noon.

EXAMPLE. On June 20th at London Latitude $51^{\circ}\frac{1}{2}$ the Sun's Declination being $23^{\circ}\frac{1}{2}$ North, it will be found that the Sun rises about $8^h\frac{1}{4}$ before Noon, or 3 Quarters after 3 in the Morning; and sets a Quarter after 8.

Hence the Length of the Day being equal to double the Sun's setting is equal to $16^h\frac{1}{2}$, and as the Sun's Declination in the Ex-

ample is the greatest, it shews that $16^{\text{h}} \frac{1}{2}$ is the longest Day at that Place.

PROBLEM VIII. To find the Length of the longest Day at any Place in the Polar Circles.

To illustrate this let the Place be Hacluit's Headland in Greenland, Lat. 80° N.

Rectify the Analemma, then you will readily see that when the Sun comes to 10° Declination (equal to the Complement of Latitude of the Place) the Sun would 12 Hours after Noon come to the Horizon in the North but not set; this corresponds to the 16th of April; from which Time the Sun being going to the Northward continues above the Horizon till it returns to 10° N. Declination again, which in the Calendar answers to the 27th of *August*. Hence it appears that it is *all Day* at that Place, from the 16th of *April* to the 27th of *August*.

In the same Manner it will be found that at the Poles, or in 90° of Latitude either North or South, there is but one Day and one Night in a whole Year.

PROBLEM IX. To find the Sun's Altitude at a given Place, at any given Day and Hour.

This admits of 3 Cases:—

First. When the Meridian Altitude is required, rectify the Analemma, then will the Parallel of Declination cut the Meridian in the Altitude required.

EXAMPLE. The Sun's Meridian Altitude at Noon at London the 1st of May, will be found to be $53^{\circ} \frac{1}{2}$.

Case 2. When the Sun's Altitude is required at the Time it is East or West.

The Analemma being rectified, observe what Degree of the Prime Vertical is cut by the Parallel of the Sun's Declination, and that will be the required Altitude.

EXAMPLE. On the above Day it will be found to be $19^{\circ} \frac{1}{4}$.

Case 3. When the Altitude is required at any other Time of the Day.

Rectify the Instrument and observe where the Parallel of Declination intersects the given Hour Circle; then placing one Leg of a Pair of Compasses on that Point, extend the other Leg to take the nearest Distance to the Horizon; then will that Distance measured on the Prime Vertical give the Altitude required.

EXAMPLE. At London Latitude $51^{\circ} \frac{1}{2}$ N. the 21st of June at 3 in the Afternoon, the Sun's Altitude will be found to be $45^{\circ} \frac{1}{2}$.

PROBLEM X. Given the Latitude of the Place, Day of the Month and Altitude of the Sun (taken by a Quadrant or other Instrument) to find the Time of the Day.

Rectify

Rectify the Analemma, then lay a String across both Meridians so that it may cut the Sun's Altitude on both Meridians; then, where the String crosses the Parallel of Declination, that is the Place of the Sun, and consequently the Hour Circle passing thro' that Place, will shew the Time required.

Let the Example be the reverse of the last Problem.

PROBLEM XI. To find the Sun's Depression at Midnight.

Rectify the Analemma, and as many Degrees as the Sun is below the Horizon, so many Degrees will the Parallel of equal Declination, but with contrary Name, be above the Horizon at the other Meridian.

EXAMPLE. In Latitude $51^{\circ} \frac{1}{2}$ North, on the 15th of April, it will be found that the Sun is $28^{\circ} \frac{1}{2}$ below the Horizon (in the North).

PROBLEM XII. To find the Beginning, and Duration of Twilight.

Twilight begins and ends when the Sun is 18° below the Horizon.

Rectify the Analemma, then laying a String across 18° of Altitude on both Meridians, observe where it intersects a Parallel of Declination equal to that of the Sun, but with opposite Name; and the Hour Circle passing through that Place will shew the Time of the Beginning of Twilight, counted from Midnight.

Thus for Example, it will be found that Twilight begins or Day breaks the 1st of October at London at $\frac{3}{4}$ after 4 in the Morning, and the Sun rises that Day at $6^h \frac{1}{4}$, so that the Duration of Twilight in the Morning is 2 Hours, and it being the same in the Evening after Sun set, will be in all, that Day, 4 Hours, which added to the Length of Day $11^h \frac{1}{2}$ gives the Time from Day-break to dark Night $15^h \frac{1}{2}$.

Note, From the End of May to the Middle of July, there is no dark Night, in the Latitude of London.

PROBLEM XIII. To find what Day of the Year the Sun will be vertical to a given Place in the Torrid Zone.

As the Latitude is counted from the Equator on the Terrestrial Globe the same Manner as the Declination is counted from the Equinoctial; we have nothing to do but to find on what Days the Sun's Declination is equal to the Latitude of the Place, and of the same Name.

EXAMPLE. Thus at Jamaica (Lat. $17^{\circ} \frac{1}{2}$ North) it will be found the Sun is vertical or passes directly over Head at that Place the 10th of May and 2d of August.

Hence it appears that those Places which lie between the Tropics may be said to have two Summers in a Year.

PROBLEM XIV. Given the Latitude of the Place, Day of the Month, and Altitude of the Sun taken (by a Quadrant) in the Fore or Afternoon, to find the Sun's Azimuth.

Rectify the Analemma and find the Sun's Declination; then laying the fiducial Edge of a Ruler to cut the Sun's Altitude on both Meridians, observe where the Edge of the Ruler cuts the Parallel of Declination, for that is the Sun's Place; against which on the Edge of the Ruler make a Mark with a Pen or Pencil, also where the Ruler crosses the Prime Vertical; then taking off the Ruler, bring the Pole to the Zenith, and the Hour Circles become Azimuth Circles. Then, placing the Ruler as before, which may be easily done by the Sun's Altitude and the Marks above directed to be made, observe which Hour (now Azimuth) Circle passes by the Sun's Place marked on the Ruler, then that Hour (or Azimuth) Circle will on the Horizon shew the required Azimuth.

EXAMPLE. At London in Lat. $51^{\circ} \frac{1}{2}$ N. the 21st of August, when the Sun's Altitude is 41° in the Forenoon, his Azimuth is S. 57° E. which is nearly 5 Points from the South towards the E. or S. E. by E. and in the Afternoon when the Sun has the same Altitude it is S. W. by W.

Note, This may also be solved by Means of the Horn hinted at in the Scholium to the next Problem.

PROBLEM XV. To find the Sun's Azimuth at any given Day and Hour at any Place.

This admits of 2 Cases.

Case 1st. At Noon or Midnight, the Sun is on the Meridian, and so must be either North or South.

Case 2d. To find the Sun's Azimuth at any other Time of the Day.

Here, as the Azimuth Circles could not be laid down on the Moveable Circle for every Latitude, that Defect may be thus supplied:

Having rectified the Analemma and found the Sun's Declination: The Place where the Parallel of Declination cuts the given Hour Circle, is the Place of the Sun for that Time. With a pair of Compasses take the nearest Distance from that Place to the Horizon, which measured on the Prime-Vertical, will shew the Sun's Altitude at that Time. This done, lay the fiducial Edge of a Ruler to cut each Meridian in the Sun's Altitude, then observe where the Ruler intersects the Place of the Sun above found, and the Prime-Vertical; against each of these Places make a Mark, with a Pen or Pencil on the Edge of the Ruler.

Now turn the moveable Circle 'till one of the Poles comes in the Zenith, then may the Hour Circles be looked on as Azimuth Circles. Then the Ruler by the Marks made on its Edge, may be

be easily placed in its former Position; which being done, observe what Hour Circle (now Azimuth Circle) intersects the Ruler at the Mark made for the Sun's Place, and carrying your Eye along that Circle 'till you come to the Horizon, you'll see the Azimuth required.

EXAMPLE. At London, the 21st of June at 3 o'Clock in the Afternoon, it will be found, that the Sun is about 6 Points from the South towards the West, that is, about W. S. W.

SCHOLIUM. If the Azimuth Circles be drawn on a Quarter of a Circle, made of clear Horn or Transparent Paper, then as the Hour Circles, &c. can be seen thro', the Azimuth may be found by Inspection. Such a Horn or Paper may be made for Six-pence; and if requested, may be had with the Instrument at that Price.

PROBLEM XVI. Given the Latitude of the Place and Day of the Month to find on what Time of the Day the Sun will be on a given Azimuth.

Rectify the Analemma, and find the Sun's Declination, then lay the Horn so that the Zenith of the Horn or Transparent Paper may be in the Zenith of the Instrument, that the Line drawn on it from the Zenith may lie on the Prime Vertical, and that the Line on it perpendicular thereto, may lie in the Horizon, &c. then we have only to observe where the given Azimuth crosses the Parallel of the Sun's Declination, and that will be the Place where the Sun is at that Time; and consequently, the Hour Circle passing by that Place, will be that required.

The Example may be the Reverse of that in Problem XV.

Of the S T A R S.

PROBLEM XVII. To find the Time of a Star's coming on the Meridian (or when its Altitude is the greatest possible for that Day) vulgarly called the Southing.

We have already given the Rule in Page 18.

EXAMPLE. What Time is *Arcturus* South, the 17th of May.

In the Table of Stars on the Instrument, the Stars

Right Ascension is	-	-	-	-	-	14 ^h	5'
The Sun's R. A. by Inspection of the Column							
R. A. of the Calendar is	-	-	-	-	-	3	38
							<hr/>
							Remains 10 27

That is, *Arcturus* is South that Night at 27 Minutes after 10.

SCHOLIUM. The Manner of Working for the Stars, Moon, Planets, &c. is so near that of the Sun, that it seems

only necessary to hint, that the Declination of the Stars being taken out of the Table of Stars, and of the Moon or Planets from an Ephemeris or Annual Almanack, work for the Stars, &c. in the same Manner as has been shewn in the Problems for the Sun; only it must be noted, that the Time found by such Operation must not be considered as so many Hours before or after Noon; but so many Hours before or after the Southing of the Star, Moon, or Planet.

Thus for Example, if it be required to find the Time of *Arcturus* Rising and Setting the 17th of *May* at London.

By rectifying the Analemma, the Declination of the Star being $20^{\circ} 24' N.$ we shall see by Inspection that its semidiurnal Arc, or Time of the Stars setting after its Southing is $7^h 50'$.

The Time of Southing being	$10^h 27'$
Subtract and add semidiurnal Arc	$7 50$

Gives Time of Rising	-	-	$2 37$	after Noon
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And the Star sets after Noon of	}	$18 17$
17 th Day		
Subtract		12

Gives Star's Setting the next	}	$6 17$
Morning at		

Many other Problems might have been given, but if the Reader rightly understands what is already delivered, he will not find it difficult to solve more, without any further Assistance.

18 AP 68
F I N I S.

ERRATA.—P. 8, Line last, for of *Good Hope*, read *Cape Horn*.

P. 9, Line 3, for *the Cape Horn*, read of *Cape Horn*.

* * * The following Books, and Instruments, &c. are published by B. DONNE, viz. Essays on Arithmetic, vulgar and decimal, Price 6s.—2. The Accomptant, with Circulating Decimals, 5s.—3. The Geometrician, with Trigonometry, 6s.—4. The British Mariner's Assistant, 6s.—5. The Navigation Scale improved, with its Use, 5s.—6. The Variation and Tide Instrument, 2s.—7. The Lunar and Tide Instrument, 2s.—8. The Nautical Pocket Piece, 6d.—9. Map of the Country eleven Miles round Bristol, 16s. 6d. fitted up.—10. Plan of the City of Bristol, 1s. 6d.—11. His Map of the County of Devon, which obtained the Premium of 100l. of the Society of Arts, &c. on 12 Sheets of Imperial Paper.—12. An abridged Map of the Country round Bristol, 4s.—13. Nautical Protractor, for expeditiously finding the Course to, or Bearing of Places on Charts and Maps, 6d.—14. A Map of the Western Circuit of England, containing the Counties of Hants, Wilts, Dorset, Somerset, Devon, and Cornwall, on 4 Sheets and a Half

